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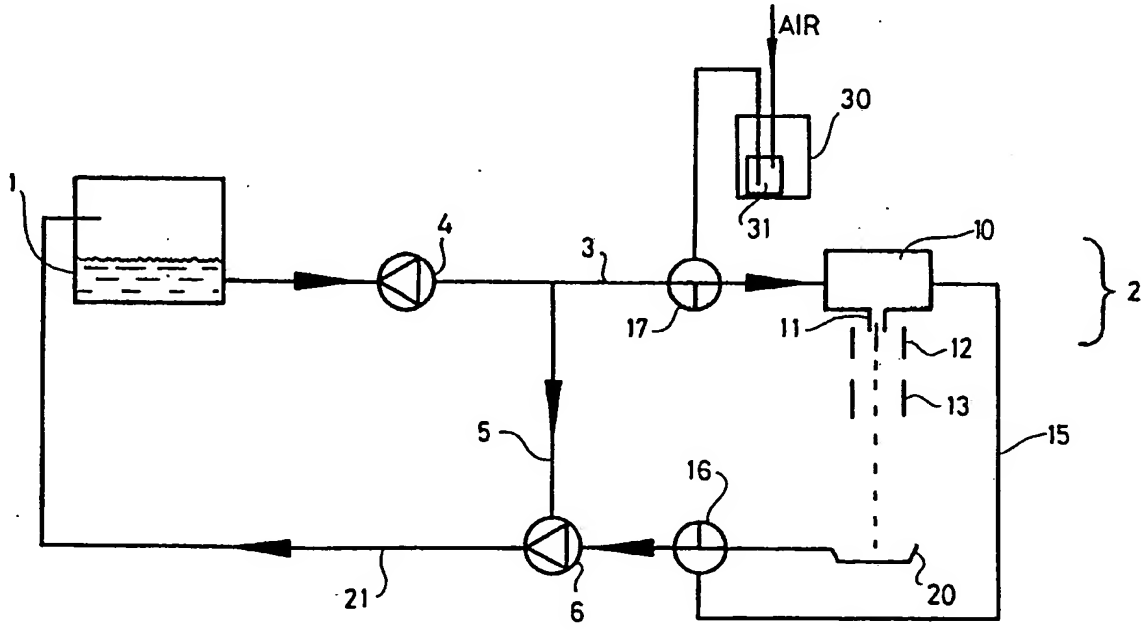
(54) Title: METHOD FOR FLUSHING AN INK FLOW SYSTEM



(57) Abstract

The present invention provides a method for flushing the ink flow system of an ink jet printer characterised in that the flushing fluid flows as plugs of fluid interspersed with plugs of air to achieve a pulsed flow of the flushing fluid. The invention also provides a device for achieving such a pulsed flow of flushing fluid from a vessel.

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Method for flushing an ink flow system

The present invention relates to a system, notably to a system for flushing ink lines in an ink jet printer.

BACKGROUND TO THE INVENTION:

Ink jet printers operate by ejecting a jet of ink or a series of droplets of ink through a fine bore nozzle orifice. Due to the very fine orifice bore, problems with blockage of the bore may arise, notably when the flow of ink through the bore is interrupted for any length of time, for example during periods between operation of the printer.

It is therefore customary to flush a solvent through the nozzle bore in order to clean the bore. It is also necessary to flush other parts of the ink flow system, for example the nozzle chamber serving the nozzle and the ink lines serving the chamber, with a solvent after a print run and before the start of a new run. In such flushing operations, clean solvent is flushed through the print head, the nozzle chamber and the nozzle bore, and the ink feed and return lines to the print head. The contaminated solvent is either discarded or recycled for use in maintaining the desired solvent level in the ink during subsequent operation of the printer. However, where large volumes of solvent are used to ensure adequate flushing of the ink system, the solvent dilutes the remaining ink excessively if returned to the ink reservoir of the printer. It is therefore often necessary to evaporate off some of the flushing solvent to reduce the dilution of the ink. Where the solvent has been passed through the nozzle bore, some evaporation of solvent inherently occurs as the solvent follows the flight path to the gutter or other catcher used to collect the flushing solvent. However, this does not occur with solvent which flushes through the ink lines, the nozzle chamber and the remainder of the print head and which does not pass through the nozzle bore.

Surprisingly, we have found that the amount of solvent required to flush out an ink jet printer can be reduced if the flow of solvent is pulsed by passing alternating pulses of solvent and air through the print head and the ink lines. The reduction in the amount of solvent used not only reduces costs, but also reduces the down time required for flushing and the possible mess caused by solvent spillage. Furthermore, where a jet pump is used to recycle ink from the gutter or catcher in a continuous ink jet printer as described below, this provides a simple means for achieving the flow of the flushing solvent through the ink flow system of the printer and enables a simplified and largely closed circuit flushing system to be achieved.

SUMMARY OF THE INVENTION:

Accordingly, the present invention provides a method for flushing residual ink from an ink jet printer, which method comprises passing a flushing fluid through at least the nozzle chamber and/or the ink conduits serving the nozzle chamber of the printer, characterised in that the flow of flushing fluid through the nozzle chamber and/or the conduits comprises pulses of solvent and air.

Surprisingly, we have found that the use of a pulsed flow of the flushing fluid reduces the amount of fluid which is required to achieve adequate removal of residual ink or solids from the nozzle chamber or the ink conduits, for example by 50% or more. The flushing fluid is preferably the solvent used as the carrier medium for the ink which is subsequently to be used in the printer, although other flushing fluids or mixtures of fluids may be used. For example, when one type of ink has been used, it may be necessary to use a ketone solvent, but the ink to be used after the flushing may require the use of an alcohol solvent which is incompatible with the ketone solvent. In such a case the flushing operation may be carried out initially with the ketone solvent to remove residual first ink and then with

the alcohol solvent to remove residues of the ketone solvent. For convenience, the invention will be described hereinafter in terms of the use of a single flushing fluid to remove residues of an ink from the printer.

Ink jet printers are of two main types. In one type ink is fed under pressure to a flow control device, such as a valve or transducer, which ejects the ink through a nozzle orifice as a single droplet as and when required. An array of nozzles is mounted in opposition to a substrate and the array and substrate move relative to one another, usually by passing the substrate past a fixed array of nozzles. By selecting the operation of the flow control devices, droplets are ejected selectively from the nozzles in the array to form a dot matrix alpha-numeric or other image on the substrate. Such types of ink jet printer are known as drop on demand printers and the term ink chamber as used herein denotes the flow control device and any manifold located upstream of the nozzle orifice in such a form of ink jet printer.

In the other main type of ink jet printer, the continuous jet type of printer, ink is fed under pressure by a circulation pump from a reservoir to a nozzle chamber in a print head from which it is ejected as a jet of ink from a nozzle orifice served by the chamber. The jet of ink is broken up into a series of substantially uniformly sized and spaced apart droplets by the application of vibration and/or pressure pulses to the ink and/or the nozzle assembly, for example by means of a piezoelectric crystal acting directly on the ink or through a wall of the nozzle chamber, which is usually immediately upstream of the nozzle orifice. The flight path of the droplets is controlled by charging the jet of ink so as to form charged droplets which then pass through a deflecting electric field. By varying the charge on the droplets and/or the strength of the deflecting field, the droplets are diverted to varying extents from their straight line flight to deposit at the desired position on a substrate. Those droplets which are

not to be printed are not deflected and are collected in a gutter or other catching means and the ink is then re-cycled to the reservoir, usually by means of a jet or other pump in the re-cycle line. In a particularly preferred method of operation, the excess ink from the circulation pump is fed via a by-pass line to the jet pump which then serves as the flow restrictor which regulates the amount of fluid flowing through the by-pass line as opposed to the print head. For convenience, the term continuous jet ink jet printers will be used herein to denote such printers.

The present invention can be applied to all types of ink jet printer, but for convenience will be described hereinafter in terms of a continuous ink jet printer.

The print head of a continuous ink jet printer typically contains a chamber immediately upstream of the nozzle orifice through which the ink is ejected, an inlet through which ink is fed to the chamber from the circulation pump and an outlet through which ink can be discharged from the chamber and which can be connected to waste or preferably to the suction side of the jet pump. Such an arrangement enables flushing fluid to pass through the ink chamber during cleaning or purging to remove debris and entrapped air. For convenience, the term print head will be used herein to denote such nozzle/chamber assemblies.

A typical ink flow system for an ink jet printer is shown in Figure 1 of the accompanying drawings.

In the method of the invention, the flushing fluid flows through the desired parts of the ink flow system, usually the print head and ink supply and return lines to the print head. Other parts of the ink flow system can also be flushed, but for convenience the flushing operation will be described hereinafter in terms of flushing out the print head.

The flushing fluid is preferably the solvent medium used as the carrier for the ink which has been printed. The solvent is preferably held in a separate flushing solvent container, which is connected to the ink flow system via a suitable valved branch from one of the ink flow lines. Alternatively, the flushing solvent may be drawn from the vessel used to contain the make up solvent which is added to the ink during operation of the printer to maintain the desired solvent level in the ink. The solvent can be fed to the ink flow system from its container under pressure, for example the pressure typically used to feed ink through the print head nozzle orifice, and this is typically done during flushing of the nozzle orifice bore. However, it is particularly preferred to draw the solvent into the ink flow circuit by connecting the outlet from the ink chamber of the print head to the suction side of the jet pump used in the ink circulation system by a suitable valved connection. In this way solvent is drawn from the solvent container under vacuum, through the chamber and the ink flow lines of the print head and the ink re-cycle lines to the reservoir in a substantially closed circuit, thus minimising losses of the solvent by evaporation.

The pulsing of the solvent flow alternates plugs of solvent with plugs of air or other vapour. It will in general be more simple and convenient to achieve the desired alternation between air and solvent by sucking air into a line under vacuum rather than feeding air under pressure into a pressurised solvent line. For convenience, the invention will be described hereinafter in terms of the use of the suction generated by the jet or other pump to circulate ink from the gutter to the reservoir as the means for circulating the solvent/air flush through the ink flow system of the printer.

Typically, the flow of flushing solvent will comprise plugs of fluid of from 0.5 to 10 mls each at intervals of from 5 to 30 seconds between each plug, air flowing through the ink flow system between each such solvent plug.

The desired plug of solvent and the interval between the plugs of solvent in the ink flow system of the printer can be achieved by the use of an intermittently operated flow control valve which regulates the flow of solvent and air into the ink flow system. However, a particularly preferred method of operation is to draw the solvent into the ink system from a container which is fed with make up solvent via a restricted inlet from a main supply of the solvent. The container is provided with an air inlet which is exposed to the suction connection between the container and the ink flow system of the printer when the solvent in the container falls below a certain level. In this way, solvent is drawn from the container until the solvent outlet from the container is exposed to the air inlet. At this point, air is drawn into the ink flow system to provide a plug of air immediately downstream of the plug of solvent. The air will continue to be drawn into the ink flow system until a valve or other flow control means interrupts the flow of air into the container, or the vacuum is no longer applied to the ink flow system and/or the container. When this occurs, solvent can flow into the container to re-fill it to the desired level above the solvent outlet to provide the next plug of fluid. The valve means is then opened to re-establish flow communication between the container and the ink flow system to draw solvent into the system and form the next solvent plug in the system.

In a particularly preferred embodiment, the container and flow restricted inlet take the form of a generally tubular housing immersed in the solvent container. The housing has a solvent removal dip tube extending to close to the base of the housing and a short air inlet tube, both extending axially into the housing through the closed upper end of the housing wall. The other, lower end of the housing is provided with one or more apertures is the transverse end wall of the housing to provide the restricted inlet through which solvent can flow into the housing.

The apertures in the base of the housing regulate the flow of solvent into the housing. These can be one or more fine apertures in the base wall of the housing. However, it is preferred to form the lower end of the housing as an open end with a foamed plastic, ceramic frit or other foraminous plug or end wall mounted therein. The optimal material for use as the foraminous plug can readily be determined by simple and trial error tests having regard to the general requirement that it takes from twice to thirty times as long to fill the housing as it does to empty it.

From another aspect, therefore, the invention provides an ink jet printer having an ink flow system which requires flushing with a flushing fluid, characterised in that the flushing fluid is supplied to the ink flow system of the ink jet printer by means of a pick up device immersed in a vessel containing the flushing fluid, which pick up device comprises a housing having a flow restricted solvent inlet, a solvent outlet connected to the flow system of the printer and an air inlet adapted to allow flow of air into the device when the level of solvent in the device falls below the level of the solvent outlet and thence into the flow system of the printer whereby the flow of flushing fluid in the ink flow system is interrupted by flows of air in the system.

By using alternating plugs of solvent and air as the flushing medium for the ink flow system of the printer, we have found that the amount of solvent required to achieve adequate flushing is reduced as compared to the use of a single long plug of fluid. Furthermore, the flow of flushing fluid through the flow system is faster since the plugs of air reduce the frictional and viscous drag on the flow of the flushing fluid, thus further enhancing its flushing effect. It is thus possible to achieve flushing with amounts of solvent which do not excessively dilute the ink in the printer reservoir. Furthermore, where the solvent is drawn through the ink flow system of the printer by the vacuum generated by the jet or

other suction pump used to re-cycle ink and solvent vapours from the gutter, it is possible to achieve a substantially closed flushing system with little solvent vapour escaping to the atmosphere.

DESCRIPTION OF THE DRAWINGS:

To aid understanding of the invention, a preferred form thereof will now be described by way of illustration with respect to the accompanying drawings in which Figure 1 is a schematic flow diagram of the ink flow system of an ink jet printer; and Figure 2 is side view of the pick up device located at the base of the solvent tank in the system of Figure 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT:

A typical continuous ink jet ink flow system is shown in Figure 1 and comprises an ink reservoir 1 from which ink is fed to a print head 2 via line 3 by circulation pump 4. The circulation pump feeds more ink than is required at the print head and the excess is recycled to the reservoir via by-pass line 5 and to the jet pump 6 which is used to re-cycle ink and solvent vapours from the gutter as described below.

The print head comprises an ink chamber 10 fed with ink from line 3. Chamber 10 has a fine bore nozzle outlet 11 to form a jet of ink. The jet is broken up into a stream of substantially uniformly sized and spaced apart droplets by a piezoelectric crystal (not shown) which imparts vibration to the nozzle assembly or pressure pulses to the ink within the chamber when a voltage is applied to it. The droplets are charged by the charge electrode 12 and pass through a deflection electrode 13 where they are either deflected to print on a substrate (not shown) or follow a straight line flight path to a gutter 20. Droplets caught in gutter 20 are re-cycled via line 21 to reservoir 1 by a jet or other suction pump 6, to the throat of which ink from circulation pump 4 is

fed. The back pressure generated by the flow restriction caused by pump 6 regulates the amount of ink which flows through the by-pass line 5 from the circulation pump 4.

The ink chamber 10 is provided with a flushing outlet line 15 which is connected via a valve 16 in line 21 to the suction side of pump 6. A solvent tank 30 contains a pick up device 31 shown in more detail in Figure 2 and the solvent outlet 43 from device 31 is connected via valve 17 in line 3 with the inlet to the ink chamber 10 of the print head 2.

As seen in Figure 2, the pick up device 31 comprises a small tubular housing 40 having a capacity of from 1 to 5 mls with one end closed by a porous plug 41, for example a foamed plastics plug. The other end is fitted with a solid plug 42 carrying an axial solvent outlet tube 43 which extends to nearly the base of the housing 40 and a much shorter axial air inlet tube 44. The tube 43 is connected to the suction side of pump 6 via valve 16, the print head 2, line 15 and valve 16, and the air inlet tube 44 is connected to atmosphere.

In operation, ink is fed to the print head 2 by pump 4 and the droplets formed from print head 2 are either printed or fed to the gutter 20 for re-cycle. Valves 16 and 17 are of the two way type and connect pump 4 with the print head and gutter 20 with pump 6 so that ink flows through the print head and is collected from gutter 20 by pump 6 for re-cycle to reservoir 1. When it is desired to flush the print head 2, valve 17 is altered to place the solvent outlet tube 43 of the device 31 in solvent tank 30 in communication with the print head and to isolate the print head from pump 4; and valve 16 is altered to place the outlet line 15 from chamber 10 in communication with the suction side of pump 6. The suction on device 31 in tank 30 draws solvent out of the housing 40 until the level of solvent drops to below the end of tube 43 to provide a plug of solvent flowing through line 3, the print head 2 and line 15 under the suction generated in pump 6 by the flow of ink from

pump 4. The ink remaining in the print head and the ink flow lines flows via line 21 to reservoir 1 and is diluted by the flushing solvent entering pump 6 via line 15.

When the housing 40 in the device immersed in solvent tank 30 has been drained, the end of tube 43 is exposed and put in communication with the air inlet 44. Air is thus drawn into tube 43 and follows the solvent plug into line 3, the print head and line 15. The flow of air into the housing 40 is allowed to continue for desired time, say about 15 to 60 seconds, and is then halted by altering valve 16 to connect pump 6 with the gutter 20 so that pump 6 no longer draws a vacuum on line 15 and hence housing 40. Housing 40 can now re-fill with solvent under the head of solvent in tank 30 until the open end of tube 43 is submersed again in solvent in housing 40. Valve 16 can be reset to allow pump 6 to draw a vacuum on housing 40 and such solvent through tube 43 until the level of solvent falls below the end of tube 43 again to allow air into tube 43. The cycle of solvent and air plugs can then be repeated as often as is required merely by altering valve 16.

CLAIMS:

1. A method for flushing residual ink from an ink jet printer, which method comprises passing a flushing fluid through at least the nozzle chamber and/or the ink conduits serving the nozzle chamber of the printer, characterised in that the flow of flushing fluid through the nozzle chamber and/or the conduits comprises pulses of solvent and air.

2. A method as claimed in claim 1, characterised in that the flushing fluid is the solvent used in the ink composition to be passed through the printer after flushing.

3. A method as claimed in either of claims 1 or 2, characterised in that the ink jet printer is a continuous jet ink jet printer.

4. A method as claimed in any one of the preceding claims, characterised in that flushing fluid passes through the nozzle orifice bore.

5. A method as claimed in any one of claim 3, characterised in that the flushing fluid is drawn through the chamber and conduits by the suction from the pump used to re-cycle ink from the catcher to the ink reservoir of the printer.

6. A method as claimed in any one of the preceding claims, characterised in that the flow of flushing solvent comprises plugs of fluid of from 0.5 to 10 mls each at intervals of from 5 to 30 seconds between each plug, interspersed by plugs of air between each such solvent plug.

7. A method as claimed in any one of the preceding claims, characterised in that flushing fluid is drawn by vacuum into the ink flow system to be flushed from a dip tube extending into a container containing the fluid fed via a restricted inlet from a source of the fluid, the container having an air

inlet which is exposed to the dip tube when the fluid in the container falls below the level of the end of the dip tube.

8. A method as claimed in claim 7, characterised in that the container comprises a generally tubular housing immersed in the solvent held in a vessel, the housing having a solvent removal dip tube extending to close to the base of the housing and a shorter air inlet tube, both extending axially into the housing through the closed upper end of the housing, the other, lower end of the housing being provided with one or more apertures in a transverse end wall of the housing to provide a restricted inlet through which solvent can flow into the housing.

9. A method as claimed in claim 8, characterised in that the apertures in the base of the housing regulate the flow of solvent into the housing so that it takes from twice to thirty times as long to fill the housing as it does to empty it.

10. A method according to claim 1 substantially as hereinbefore described with respect to the accompanying drawings.

11. An ink jet printer having an ink flow system which requires flushing with a flushing fluid, characterised in that the flushing fluid is supplied to the ink flow system of the ink jet printer by a means for generating alternating pulses of flushing fluid and air during flushing of the ink flow system of the printer.

12. A printer as claimed in claim 11, characterised in that the flushing fluid is supplied to the ink flow system of the printer by means of a pick up device immersed in a vessel containing the flushing fluid, which pick up device comprises a housing having a flow restricted solvent inlet, a solvent outlet connected to the flow system of the printer and an air inlet adapted to allow flow of air into the device when the level of solvent in the device falls below the level of the

solvent outlet and thence into the flow system of the printer whereby the flow of flushing fluid in the ink flow system is interrupted by flows of air in the system.

13. An ink jet printer as claimed in either of claims 11 or 12, characterised in that the ink flow system of the printer is connected to the suction side of a jet pump adapted to circulate ink to the ink reservoir of the printer, whereby suction can be applied to the source of flushing fluid to draw the fluid through the ink flow system of the printer.

14. An ink jet printer substantially as hereinbefore described with respect to the accompanying drawings.

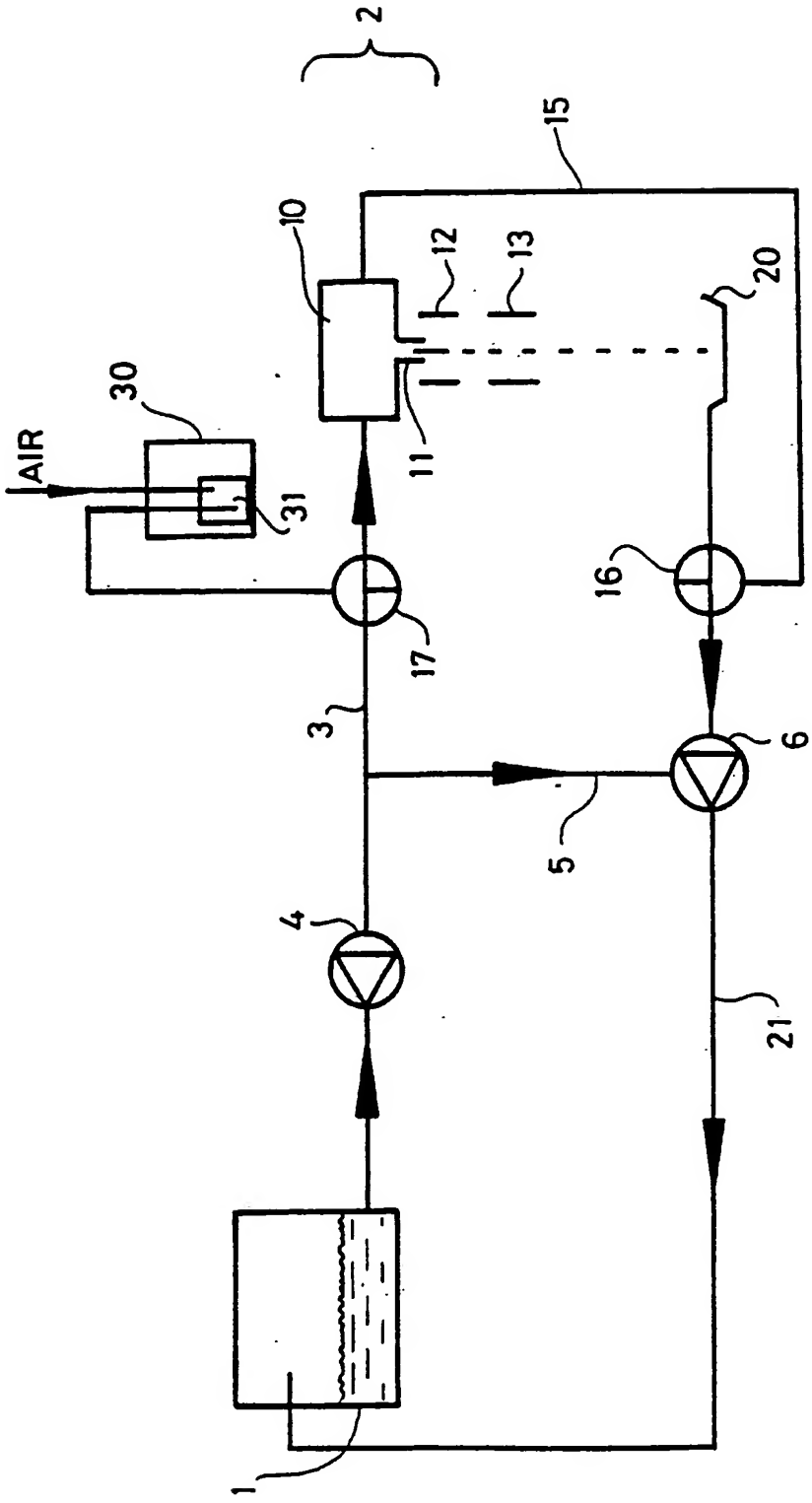

Fig. 1

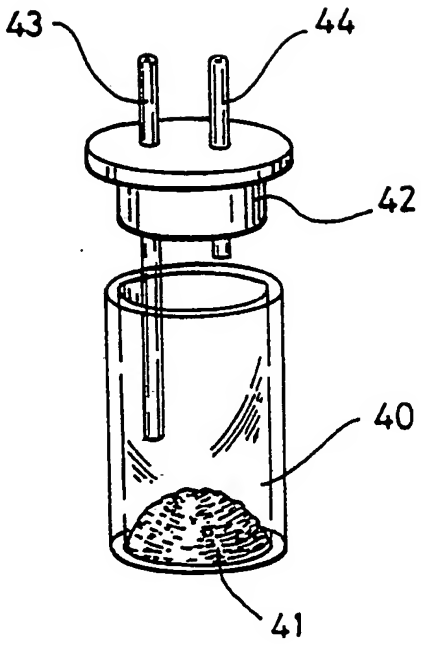

Fig. 2

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 93/00522

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 B41J2/165

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	B41J

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	PATENT ABSTRACTS OF JAPAN vol. 8, no. 253 (M-339)(1690) 20 November 1984 & JP,A,59 127 767 (EPUSON K.K.) 23 July 1984 see abstract	1-14
X	US,A,4 296 418 (YAMAZAKI ET AL.) 20 October 1981 see column 1, line 51 - line 58; figure 1	1-7, 10-14
A	US,A,4 023 182 (ARWAY ET AL.) 10 May 1977 see claim 1; figure 2	7,8,9
A	EP,A,0 317 267 (CANON K.K.) 24 May 1989 see claim 1	1-14

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° Special categories of cited documents : [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
10 JUNE 1993	29.06.93
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	JOOSTING T.E.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	US,A,3 891 121 (STONEBURNER) 24 June 1975 see column 2, line 25 - line 54; claims 1,2	1-14

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

GB 9300522
SA 71180

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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